

DESIGN FOR POWER PLANT

P. E. HENWOOD

ARMOUR INSTITUTE OF TECHNOLOGY

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Design for power plant

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DESIGN
FOR
POWER PLANT
A THESIS

PRESENTED BY

PROCTOR E. HENWOOD

TO THE

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

HAVING COMPLETED THE PRESCRIBED COURSE OF STUDY IN

MECHANICAL ENGINEERING

MAY 20, 1910.

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SCOPE OF THIS THESIS.

A corporation in the City of Chicago has at present two buildings located within the loop district. One of these buildings is devoted to office use; the other to light manufacturing and jobbing concerns. It is proposed that a new building will be erected to be devoted to manufacturing purposes, its location being on the Chicago River. See Map. The power for lighting and operating the elevators in the two buildings mentioned is purchased from a central station. A low pressure steam heating system furnishes heat for both buildings.

The economical questions are: First, will it pay to operate the three buildings as one unit, i.e., with a plant located in the new building; Second, what will be the cost of such a plant; Third, the probable revenue to be derived; and Fourth, the cost of operation.

Operation of three buildings as one unit.

Under the present method of operation the following help is employed: A Chief Engineer, one Assistant Engineer and two firemen; this is for the winter months. Through the summer months when the heating system is not in use the firemen can be dispensed with, as the Assistant Engineer can tend the hot water fire during the day and the night watchman at night. With one large plant the above help increased by one assistant engineer, one fireman and one oiler, is ample for operation at all times. Also owing to the fact that all labor and fuel are at one point, operation will be cheaper than with two smaller plants. As the plant would be near the river it can be operated condensing with high economy through the summer months. The tunnel of the Illinois Tunnel Company to the other building affords an easy means for transmission of steam and electric current.

Description of Plant.

The plant consists of water tube boilers fed by chain grate stokers, overhead coal bunkers, and coal and ash handling machinery. High speed compound engines running condensing direct connected to direct current generators. Coal will be delivered through the tunnel or by wagons direct to storage bin without extra handling.

Estimated Cost of Plant.

The plant is estimated to cost \$60,000. of which amount \$46,000. is required for the electric plant and \$4,000. for heating.

Estimated Annual Gross Revenue.

It is expected that all light and motive power required by the tenants will be furnished by this plant. The estimated amount of current from which a revenue can be derived is 420,000 kilowatt hours. Computing this at a metered rate of 10¢ per kilowatt hour, with a rebate of 1¢ per kilowatt hour for prompt payment, i.e., 9¢ gives \$37,800. This price of 9¢ per kilowatt is the rate at which the Commonwealth Edison Co. furnishes current for individual lighting.

Estimated Cost to Operate Plant.

Interest 4.5%, Depreciation 5% insurance
and taxes 2% = 11-1/2% on \$60,000. \$6,900.00

Fuel -

845,000 KW hrs. @ 8#	- - -	3380 tons	
Standby losses 1-1/2 tons per day		548	
		<u>3928</u>	"
3928 tons @ \$1.50 + .50	= - - - - -		7,856.00

Labor -

1 Chief Engineer	\$150.00 per mo.	
2 Asst. Engineers @ \$85.00	170.00	
1 Oiler	70.00	
3 Firemen @ \$75.00	225.00	
1 Helper for Bldgs. "A" & "B"	75.00	
	<u>690.00</u>	per month.

Labor for 12 months - - - - - 8,280.00

Hauling ashes - - - - -	300.00
Machinery Repairs - - - - -	350.00
Supplies, packing, oil and waste - - - - -	400.00
Tunnel Rental - - - - -	<u>2,000.00</u>
	26,086.00

Revenue.

The estimated revenue will be as follows:

Estimated Gross Revenue: (See page 28)
420,000 KW Hrs. @ 9¢ per KW hr. 37,800.00

Estimated Net Revenue - - - - - 11,714.00

Investment in plant other than that required
for heating = \$60,000. - \$14,000. = \$46,000.

Return on investment of \$46,000. = 25%

DETAILED EXHIBIT .

- - o - -

The following pages contain a more detailed Exhibit.

Respectfully submitted ,

Proctor E. Newwood

DETAILED EXHIBIT.

- - -

The following pages contain the detailed exhibit.

Respectfully submitted,

James H. [Signature]

Design of a Power Plant.

With the location given the design of a power plant can be divided into two general parts: first the requirements, and second the design of the apparatus to meet the requirements.

The requirements of a power plant are,- that it shall furnish at all times a stated amount of power in some form as light, heat or refrigeration, or that it can furnish power direct as electric current for conversion, for either individual or commercial use.

The design of a power plant in general depends upon the form of energy desired. Individually the design is broad and variable, being influenced by many factors, such as accessibility to fuels, kinds of fuel and their costs, availability of water supply and its purity. The most important factor is the load, for upon this the efficiency of the plant is based. When the load is constant and at full rating the highest efficiency can be obtained, but with a variable load and at low rating the efficiency falls off and operation becomes costly.

The plant under consideration has been designed to meet the requirements of typical office and light manufacturing buildings, and will furnish light, heat and power. Owing to the location of this plant it is expected that power can be sold, and to this end reserve power has been installed.

The plant will operate condensing during the summer months, while in the winter the exhaust steam will be used for heating the buildings. All power necessary for operating elevators and such appliances as the buildings may contain will be furnished by this plant. Also it is intended to furnish the lighting and motor power to the tenants of the buildings.

The power generators will be four High Speed Engines direct, connected to direct current generators, as follows:

Unit # 1

75 H.P. Simple with 50 K W Generator

Unit #2

150 H.P. Compound with 100 K W Generator

Units #3 and #4

225 H. P. Compound with 150 K W Generator

A condenser of the surface type will be used in conjunction with Unit #2, #3 or #4.

Four boilers will be installed in batteries of two boilers each, they will be water tube type, fed by chain grates, each boiler being 250 H.P. to contain 2500 sq. ft. of heating surface and operate a steam pressure of 160# per square inch. The grates will have an

Design of a Power Plant

With the location given the design of a power plant can be divided into two main parts: First the preliminary, and second the design of the apparatus to meet the requirements.

The requirements of a power plant are: - That it shall furnish at all times a stated amount of power in some form or form, heat or refrigeration, or that it shall furnish power direct or indirectly for conversion, for other industrial or commercial uses.

The design of a power plant is especially dependent upon the form of energy desired. Individually the design is broad and variable, being influenced by many factors, such as accessibility to fuels, kinds of fuel and their costs, availability of water supply and its position. The most important factor is the load, for upon this the efficiency of the plant is based. When the load is constant and at full rating the highest efficiency can be obtained, but when the load is at low rating the efficiency falls off and operation becomes costly.

The plant under consideration has been designed to meet the requirements of typical office and light manufacturing buildings, and will furnish light, heat and power. Owing to the location of this plant it is expected that power can be sold, and for this end reserve power has been installed.

The plant will operate continuously during the summer months, while in the winter the exhaust steam will be used for heating the buildings. All power necessary for operation of lights and other appliances as the buildings are occupied will be furnished by this plant. Also this is intended to furnish the lighting and other power to the tenants of the buildings.

The power generated is electric but will be used in mechanical form connected to direct current generators, as follows:

Unit #1
75 H.P. generator with 50 T.W. generator
Unit #2
150 H.P. generator with 100 T.W. generator
Unit #3 and #4
250 H.P. generator with 150 T.W. generator

A condenser of the surface type will be used in conjunction with Unit #2, #3 and #4.

Four boilers will be installed in parallel in operation of two boilers each, they will be water tube type, and be of the vertical type, each boiler being 250 H.P. and contain 1500 sq. ft. of heating surface and operate at a steam pressure of 150 lbs. per square inch. The boilers will have an

area of 63 sq. ft., being 9 feet long by 7 feet wide.

The furnace has been designed for a low grade Illinois coal "Springfield District" and with the large tile roof will insure smokeless combustion. In the floor of the combustion chamber is a small opening that connects with the ash hopper and affords an easy method of removing the light ashes. Sufficient room has been allowed in front of the boilers for removal of tubes and stoking grates in case of repairs. Each battery of boilers enclosed a building column, but at a distance sufficient to allow for an air space around the column. The piping has been arranged with the view of being easy of access, runways being provided over the boilers and along the steam header.

Provision has been made for the delivery of coal by wagons or through the Illinois Tunnel, the floor of the boiler room being at the tunnel grade.

Coal received by the tunnel may be delivered in front of the boilers for hand firing, or dumped into a hopper from which a bucket conveyer will carry it either to overhead bunkers or to the storage bin. Coal received by wagons will be dumped directly into the storage bin, from where it will be fed into the bucket conveyer, thence to bunkers, or by hand carts to the front of the boilers. The ashes will be elevated to the ash bin from which it may be drawn off into the tunnel cars or into a push cart, and taken by an elevator to the surface.

Water from the heating systems in Buildings "A" and "B" will be returned to the plant by means of a centrifugal pump direct, connected to a D. C. motor. The pump will be located at about tunnel grade in Building "A" with its suction attached to a tank conveniently located.

Two duplex boilers feed pumps of the ram pattern are to be installed, the dimensions being 7-1/2" x 5" x 6".

An open type of feed water heater will be used, the exhaust steam from the boiler feed pumps, the condenser pump and the stoker engines being used for heating.

area of 63 sq. ft., being a flat roof of 100 sq. ft.

The furnace has been designed for a low grade Illinois coal "Springfield District" and with the life roof will insure smokeless combustion. In the floor of the combustion chamber a small opening that connects with the boiler and affords an easy method of removing the light ash. Sufficient room has been allowed in front of the boiler for removal of tubes and staying greater in case of repairs. Each set of boiler contains a building column, but at a distance sufficient to allow for an air space around the column. The boiler has been arranged with the view of being easy of access, runway being provided over the boiler and along the steam header.

Provision has been made for the delivery of coal by wagon or through the Illinois Tunnel, the floor of the boiler room being at the tunnel grade.

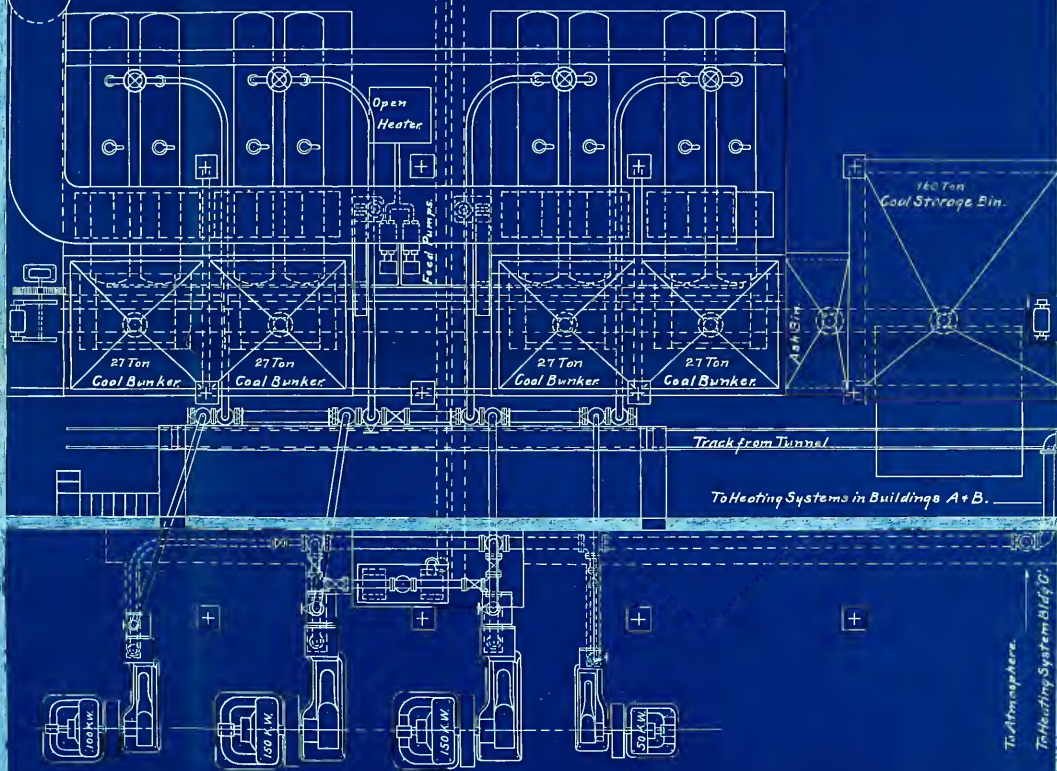
Coal received by the tunnel will be delivered in front of the boiler for hand firing, or conveyed into a hopper from which a conveyor will carry it either to overhead hoppers or to the storage bin. Coal received by wagon will be conveyed directly into the storage bin, from where it will be fed into the bucket conveyor, thence to hoppers, or by hand carts to the front of the boiler. The ashes will be elevated to the main bin from which it may be drawn into the tunnel cars or into a yard car, and taken to an elevator to the surface.

Water from the heating system in buildings "A" and "B" will be returned to the plant by means of a concealed pump direct, connected to a D. C. motor. The pump will be located at about tunnel grade in building "A" with the suction pipe at 10' and conveniently located.

Two duplex boiler feed pumps of the type referred to as installed, the dimensions being 7-1/2" x 6" x 6".

An open type of feed water heater will be used, the exhaust steam from the boiler feed pumps, the condenser pump and the steam engines being used for heating.

Chicago River

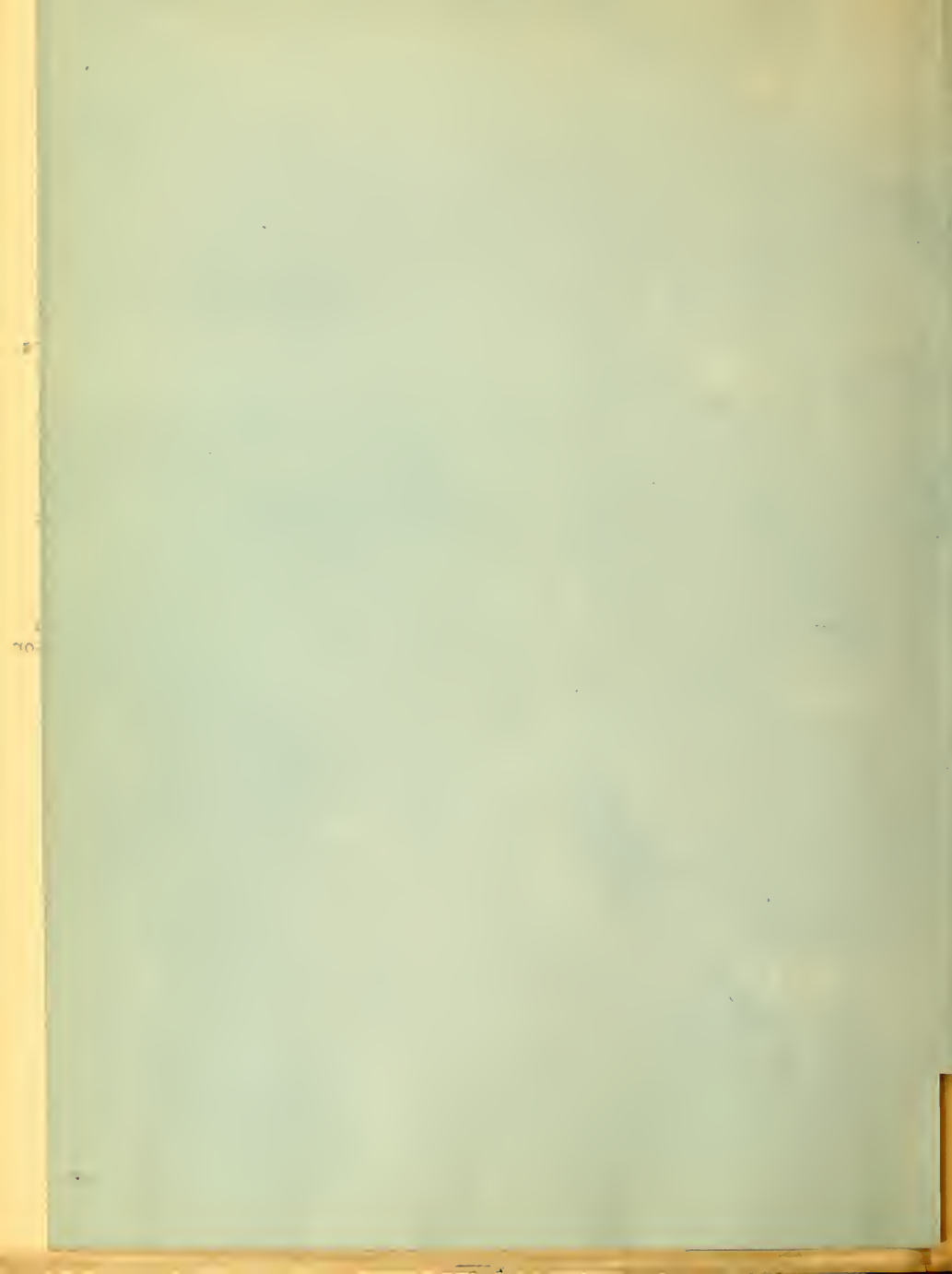


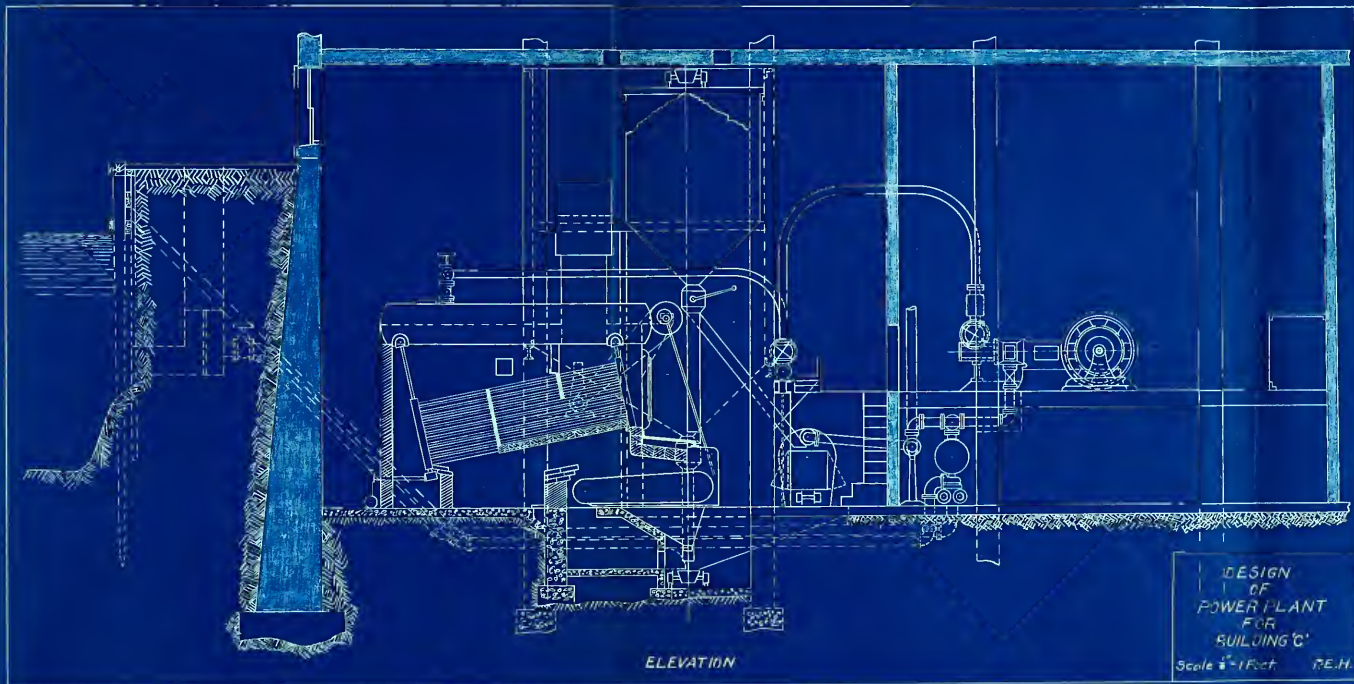
Switchboard

PLAN

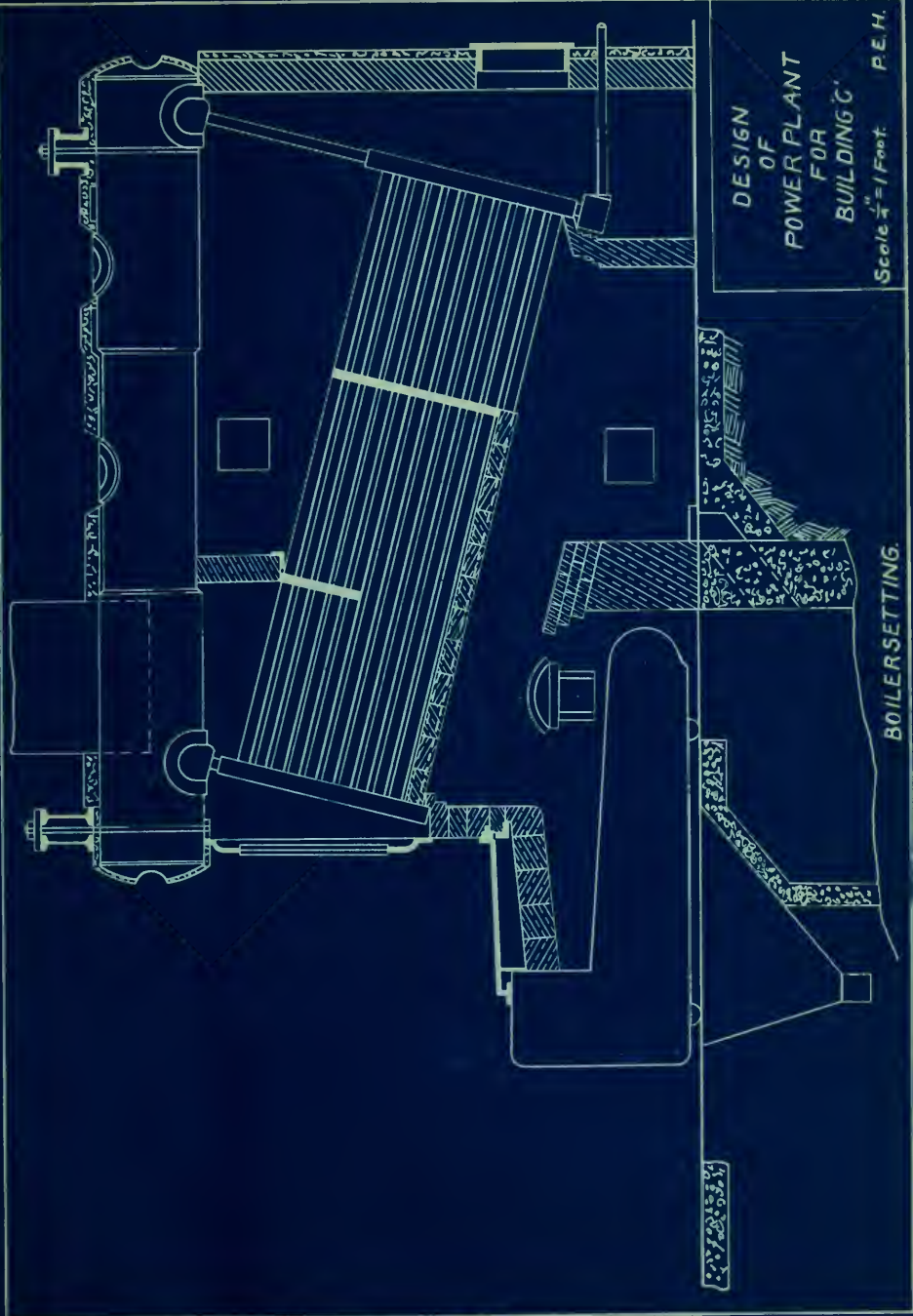
DESIGN
OF
POWER PLANT
FOR
BUILDING C

Scale 1/4" = 1 Foot P.E.H.

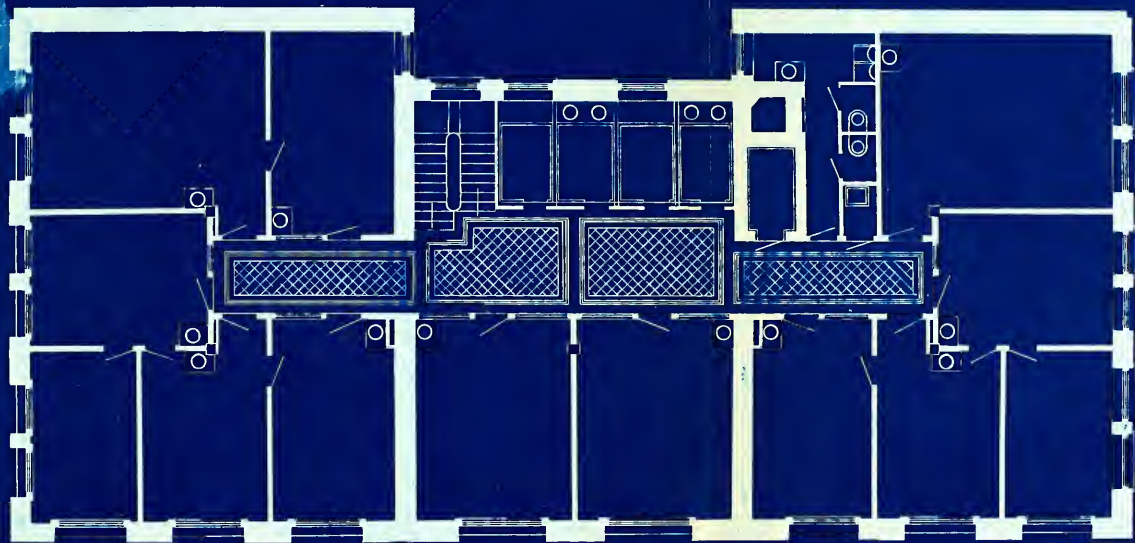








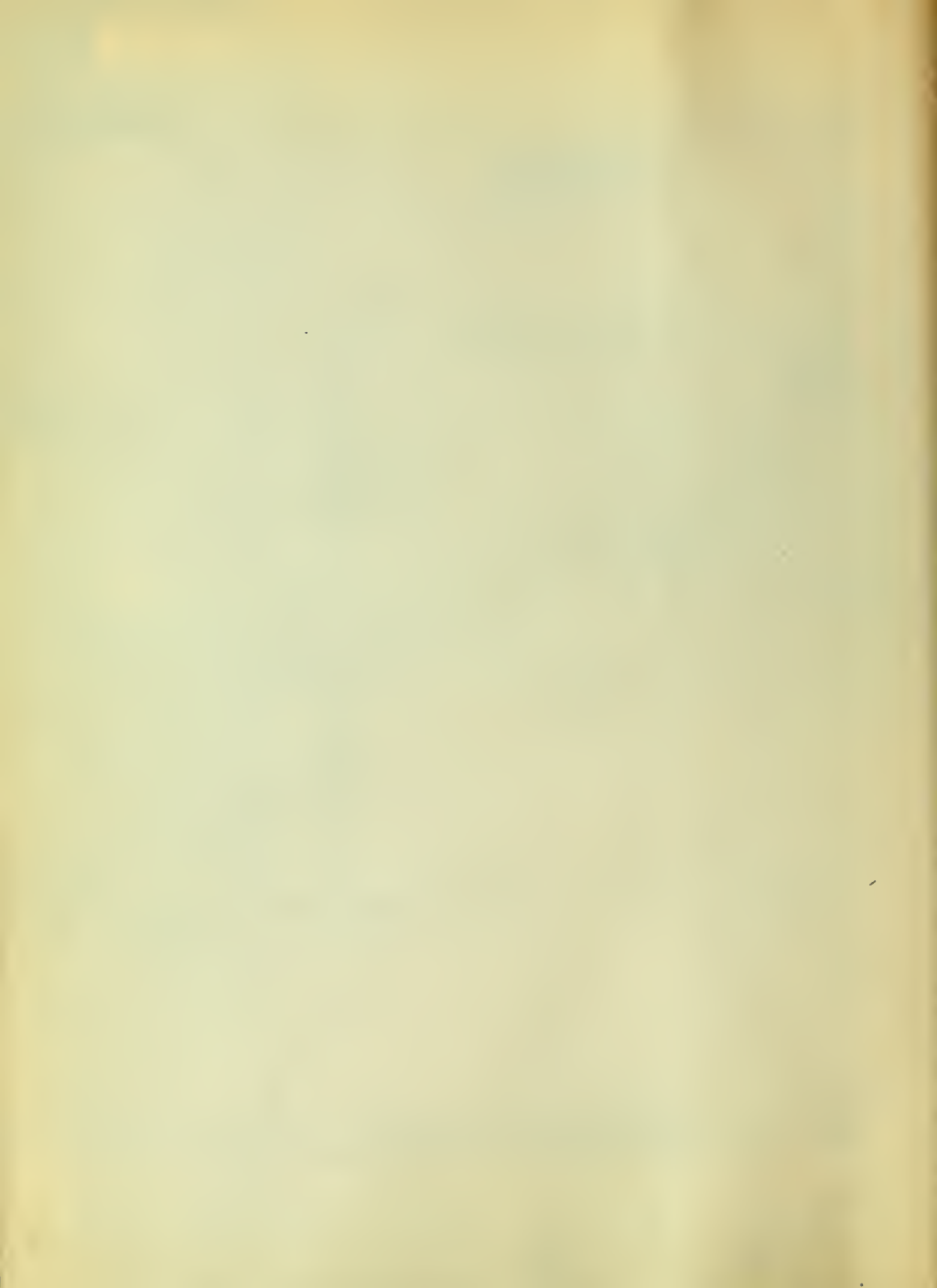


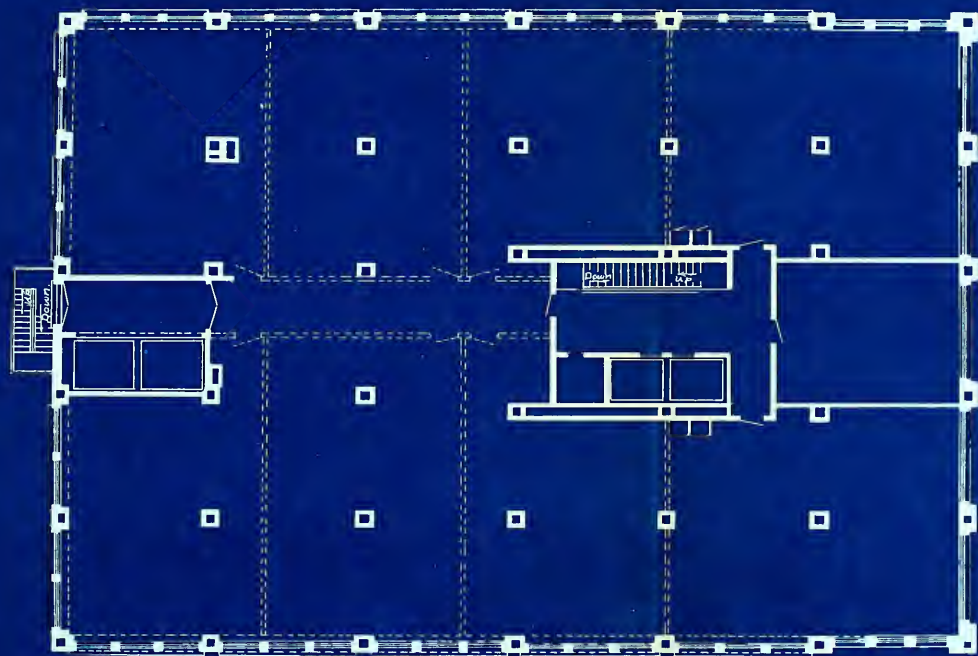


0 5 10 15 20 FEET
SCALE.

FLOOR PLAN OF BUILDING A

Figure 4.





0 5 10 15 20 feet
SCALE

FLOOR PLAN OF BUILDING 'B'

Figure 5.



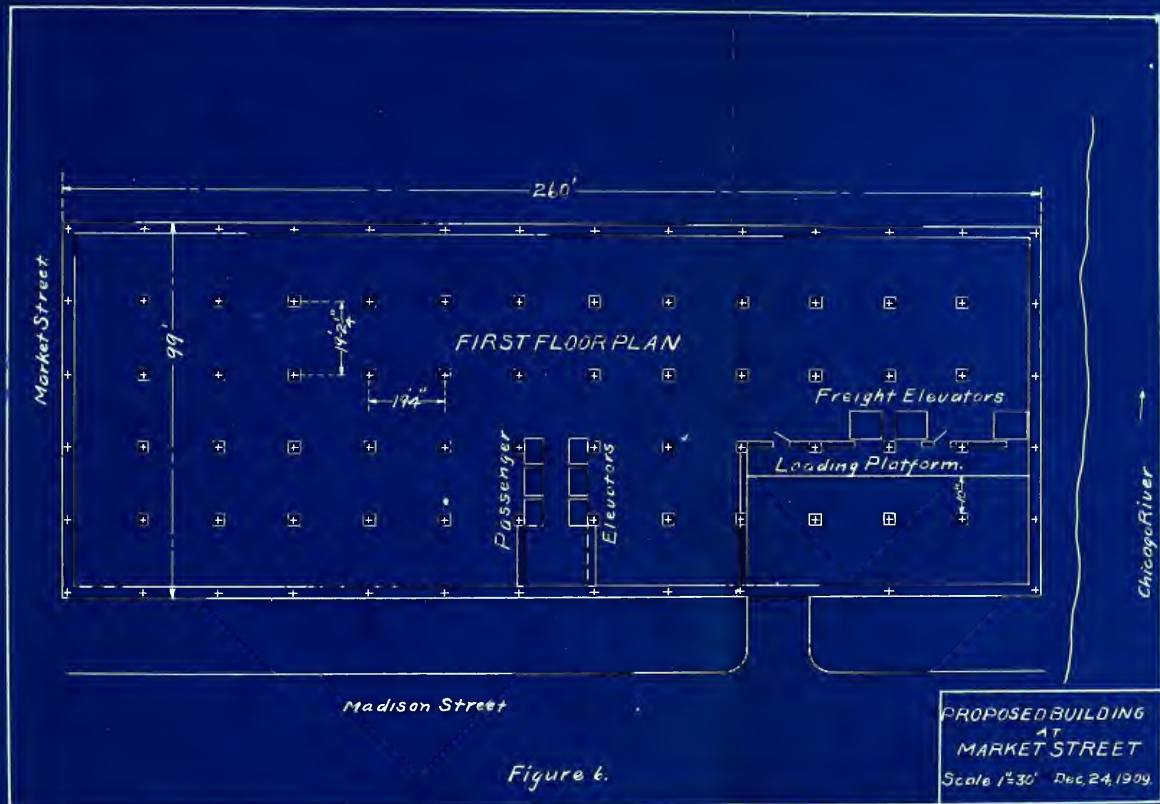


Figure 6.



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GENERAL DATA

	Bldg. "A"	Bldg. "B"	Bldg. "C"
<u>Floor Space</u>			
Length	100.75'	111.28'	257'
Width	44.8'	75.67'	96'
Area in Sq. Ft.	4502.6	8420.6	24672

<u>Stories</u>	14	12	14
Height of - Average	11'	11.5'	10'

<u>Glass Surface</u> <u>in Sq. Ft.</u>			
North Exposure	3349	6321	16435
West "	5143	5174	7350
South "	3369	9177	16170
East "	4600	3929	7525

<u>Wall Exposure</u> <u>exclusive of glass</u> <u>in sq. ft.</u>			
North Exposure	3572.6	8979	20316
West "	10422.8	5230	6378
South "	3552.6	6123	20581
East "	10965.8	6475	6203

<u>Total Wall Exposure</u> <u>Glass Equivalent</u> <u>in Sq. Ft.</u>	20535	28572	55473
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<u>Cubic Feet of Air</u> <u>in Building</u>	748682	1372804	4234208
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Type of Heating System	Steam Vacuum	Steam Vacuum	Steam Vacuum
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Radiation in Sq. Ft.	5062	7042	13672
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Determination of Radiating Surface for Heating.

The overall dimensions of the buildings were taken, thus giving the total area in square feet of the walls. From the area of each wall was deducted the area of all the openings in the wall, the openings being considered as glass. These areas are all noted according to their exposure; as North, South, East and West walls. The radiating surface was determined from these areas by means of a formula by Professor Carpenter, and is as follows:

Determination of Radiation Surface for Westing.

The overall dimensions of the building were taken, care being taken to note the location of all openings. From the area of each wall was deducted the area of all the openings in the wall, the openings being considered as glass. These areas are all noted according to their exposure; as North, South, East and West walls. The radiation surface was determined from these areas by means of a formula of Professor Schmidt, and is as follows:

Building "A"

Exposed Area In Glass Equivalent.

[illegible]

North Wall	-	-	-	-	-	-	3572.6 Sq. Ft.
West	"	-	-	-	-	-	10422.8 " "
South	"	-	-	-	-	-	3552.6 " "
East	"	-	-	-	-	-	10965.8 " "
Total	-	-	-	-	-	-	<u>28513.8</u>

Total Glass	- - - - -	16695 Sq. Ft.
10% N.	" - - - - "	335 " "
10% W.	" - - - - "	514 " "
10% Total Wall Glass Equivalent		2851 " "
10% N.	" " "	36 " "
10% W.	" " "	104 " "
Total	- - - - -	<u>20535</u>

Exposed Area - 17.5 sq. ft.

North Glass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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Total	-	-	-	-	-	8897.8
Habit	-	-	-	-	-	10496.8
" "	-	-	-	-	-	3095.8
Southern	-	-	-	-	-	10433.8
Went	-	-	-	-	-	3875.8
Northern White	-	-	-	-	-	3875.8
Tot.	-	-	-	-	-	3875.8

[illegible]

Building "B"

Exposed Area In Glass Equivalent.

North glass	-	-	-	-	-	-	-	6321	Sq. Ft.	
West	"	-	-	-	-	-	-	5174	"	"
South	"	-	-	-	-	-	-	9177	"	"
East	"	-	-	-	-	-	-	3929	"	"
Total	-	-	-	-	-	-	-	<u>24601</u>		

North Wall	-	-	-	-	-	-	-	8979	Sq. Ft.	
West	"	-	-	-	-	-	-	5230	"	"
South	"	-	-	-	-	-	-	6123	"	"
East	"	-	-	-	-	-	-	6475	"	"
Total	-	-	-	-	-	-	-	<u>26807</u>		

Total Glass	-	-	-	-	-	-	-	-24601	Sq. Ft.	
10% N.	"	-	-	-	-	-	-	632	"	"
10% W.	"	-	-	-	-	-	-	517	"	"
10% Total Wall glass Equivalent								2680	"	"
10% N.	"	"						90	"	"
10% W.	"	"						52	"	"
Total	-	-	-	-	-	-	-	<u>28572</u>		

Building "C"

Exposed Area In Glass Equivalent.

North Glass	-	-	-	-	-	-	-	16435	Sq. Ft.
West	"	-	-	-	-	-	-	7350	" "
South	"	-	-	-	-	-	-	16170	" "
East	"	-	-	-	-	-	-	7525	" "
Total	-	-	-	-	-	-	-	<u>47480</u>	

North Wall	-	-	-	-	-	-	-	20316	Sq. Ft.
West	"	-	-	-	-	-	-	6378	" "
South	"	-	-	-	-	-	-	20581	" "
East	"	-	-	-	-	-	-	6203	" "
Total	-	-	-	-	-	-	-	<u>53478</u>	

Total Glass	-	-	-	-	-	-	-	47480	Sq. Ft.
10% N.	"	-	-	-	-	-	-	1643	" "
10% W.	"	-	-	-	-	-	-	735	" "
10% Total Wall glass Equivalent	-	-	-	-	-	-	-	5348	" "
10% N.	"	"			"			203	" "
10% W.	"	"			"			64	" "
Total	-	-	-	-	-	-	-	<u>55473</u>	

1871

Extorted Area in Glasgow, Scotland.

North	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431	2432	2433	2434	2435	2436	2437	2438	2439	2440	2441	2442	2443	2444	2445	2446	2447	2448	2449	2450	2451	2452	2453	2454	2455	2456	2457	2458	2459	2460	2461	2462	2463	2464	2465	2466	2467	2468	2469	2470	2471	2472	2473	2474	2475	2476	2477	2478	2479	2480	2481	2482	2483	2484	2485	2486	2487	2488	2489	2490	2491	2492	2493	2494	2495	2496	2497	2498	2499	2500	2501	2502	2503	2504	2505	2506	2507	2508	2509	2510	2511	2512	2513	2514	2515	2516	2517	2518	2519	2520	2521	2522	2523	2524	2525	2526	2527	2528	2529	2530	2531	2532	2533	2534	2535	2536	2537	2538	2539	2540	2541	2542	2543	2544	2545	2546	2547	2548	2549	2550	2551	2552	2553	2554	2555	2556	2557	2558	2559	2560	2561	2562	2563	2564	2565	2566	2567	2568	2569	2570	2571	2572	2573	2574	2575	2576	2577	2578	2579	2580	2581	2582	2583	2584	2585	2586	2587	2588	2589	2590	2591	2592	2593	2594	2595	2596	2597	2598	2599	2600	2601	2602	2603	2604	2605	2606	2607	2608	2609	2610	2611	2612	2613	2614	2615	2616	2617	2618	2619	2620	2621	2622	2623	2624	2625	2626	2627	2628	2629	2630	2631	2632	2633	2634	2635	2636	2637	2638	2639	2640	2641	2642	2643	2644	2645	2646	2647	2648	2649	2650	2651	2652	2653	2654	2655	2656	2657	2658	2659	2660	2661	2662	2663	2664	2665	2666	2667	2668	2669	2670	2671	2672	2673	2674	2675	2676	2677	2678	2679	2680	2681	2682	2683	2684	2685	2686	2687	2688	2689	2690	2691	2692	2693	2694	2695	2696	2697	2698	2699	2700	2701	2702	2703	2704	2705	2706	2707	2708	2709	2710	2711	2712	2713	2714	2715	2716	2717	2718	2719	2720	2721	2722	2723	2724	2725	2726	2727	2728	2729	2730	2731	2732	2733	2734	2735	2736	2737	2738	2739	2740	2741	2742	2743	2744	2745	2746	2747	2748	2749	2750	2751	2752	2753	2754	2755	2756	2757	2758	2759	2760	2761	2762	2763	2764	2765	2766	2767	2768	2769	2770	2771	2772	2773	2774	2775	2776	2777	2778	2779	2780	2781	2782	2783	2784	2785	2786	2787	2788	2789	2790	2791	2792	2793	2794	2795	2796	2797	2798	2799	2800	2801	2802	2803	2804	2805	2806	2807	2808	2809	2810	2811	2812	2813	2814	2815	2816	2817	2818	2819	2820	2821	2822	2823	2824	2825	2826	2827	2828	2829	2830	2831	2832	2833	2834	2835	2836	2837	2838	2839	2840	2841	2842	2843	2844	2845	2846	2847	2848	2849	2850	2851	2852	2853	2854	2855	2856	2857	2858	2859	2860	2861	2862	2863	2864	2865	2866	2867	2868	2869	2870	2871	2872	2873	2874	2875	2876	2877	2878	2879	2880	2881	2882	2883	2884	2885	2886	2887	2888	2889	2890	2891	2892	2893	2894	2895	2896	2897	2898	2899	2900	2901	2902	2903	2904	2905	2906	2907	2908	2909	2910	2911	2912	2913	2914	2915	2916	2917	2918	2919	2920	2921	2922	2923	2924	2925	2926	2927	2928	2929	2930	2931	2932	2933	2934	2935	2936	2937	2938	2939	2940	2941	2942	2943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Direction	North	West	South	East	Total
North West	50318	8378	50318	8378	110000
West		8378		8378	16756
South			50318	8378	58696
East				8378	8378
Total	50318	16756	58696	16756	122526

[illegible]

Radiating Surface.

Building "A"

From Carpenter on "Heating and Ventilation"
we have the following formula:

$$B(t - t_1) = C(T - t)R \quad \text{or} \quad R = \frac{B(t - t_1)}{C(T - t)}$$

Where: t_1 = Outside Temperature = 0°
 t = Room " = 70°
 T = Steam " = 212°
 B = Sq. Ft. of exposed area in glass equivalent
 R = Radiating Surface in Sq. Ft.
 C = Heat Units per Sq. Ft. per degree per hour from
radiating surface

$$R = \frac{20535(70-0)}{2(212-70)} = 5062 \text{ Sq. Ft. or } 1437450 \text{ BTU per hour in zero weather}$$

As the mean cold temperature is about 35° only $1/2$ this heat is necessary, or 718725 BTU per hour.

Building "B"

$$R = \frac{28572(70-0)}{2(212-70)} = 7042 \text{ Sq. Ft. or } 2,000,000 \text{ BTU per hour in zero weather}$$

As the mean cold temperature is about 35° only $1/2$ this heat is necessary, or 1,000,000 BTU per hour.

Building "C"

$$R = \frac{55473(70-0)}{2(212-70)} = 13672 \text{ Sq. Ft. or } 3883110 \text{ BTU per hour in zero weather}$$

As the mean cold temperature is about 35° only $1/2$ this heat is necessary, or 1941555 BTU per hour

Radiating Surface.

Building "A"

From Correlation on "Radiating and Ventilation"
we have the following formula:

$$R(t_1 - t_2) = C(t_1 - t_2) + \frac{C(t_2 - t_3)}{C(t_1 - t_2)}$$

Where: t_1 = Outside Temperature = 30°
 t_2 = Room " " = 70°
 t_3 = Street " " = 32°
 R = Sq. Ft. of exposed area (in glass equivalent)
 C = Radiating Surface in Sq. Ft.
 C = Heat Units per Sq. Ft. per degree per hour from
 radiating surface

$$R = \frac{20000(70-30)}{2(32-70)} = 5000 \text{ sq. ft. or } 132000 \text{ BTU per hour in zero weather.}$$

As the mean cold temperature is about 32° only 1/2 this heat is
 necessary, or 13200 BTU per hour.

Building "B"

$$R = \frac{38000(70-30)}{2(32-70)} = 7040 \text{ sq. ft. or } 1,000,000 \text{ BTU per hour in zero weather.}$$

As the mean cold temperature is about 32° only 1/2 this heat is
 necessary, or 1,000,000 BTU per hour.

Building "C"

$$R = \frac{55470(70-30)}{2(32-70)} = 12000 \text{ sq. ft. or } 1,600,000 \text{ BTU per hour in zero weather.}$$

As the mean cold temperature is about 32° only 1/2 this heat is
 necessary, or 1,600,000 BTU per hour.

Additional Heat Necessary Due To Ventilation.

Allowing:- two changes of air per hour. That one BTU will heat 55 cu. ft. one degree. That two BTU are radiated per sq. ft. of radiating surface per degree difference per hour. That the temperature rise is from 35° to 70° F.

Building "A"

Cubic contents of building = 748682 cu. ft.

$$\frac{35 \times 748682 \times 2}{55} = 952868 \text{ BTU}$$

Steam.

BTU supplied per hour (1437450 + 952868) = 2390318

Available heat per pound steam @ 212° = 970 BTU

2390318 ÷ 970 = 2464# steam in zero weather, or 1723# in ordinary weather.

Building "B"

Cubic contents of building = 1372804 cu. ft.

$$\frac{35 \times 1372804 \times 2}{55} = 1747223 \text{ BTU}$$

Steam.

BTU supplied per hour (2,000,000 + 1747223) = 3747263

Available heat per pound steam @ 212° = 970 BTU

3747263 ÷ 970 = 3862# steam in zero weather, or 2832# in ordinary weather.

Building "C"

Cubic contents of building = 4234208 cu. ft.

$$\frac{35 \times 4234208 \times 2}{55} = 5388992 \text{ BTU}$$

Steam.

BTU supplied per hour (3883110 + 5388992) = 9272102

Available heat per pound steam @ 212° = 970 BTU

9272102 ÷ 970 = 9559# steam in zero weather, or 7557# in ordinary weather.

Additional Heat Necessary Due to Ventilation.

Allowing:- two changes of air per hour. That one T.H. will heat 55 cu. ft. one hour. The two are radiated per sq. ft. of radiating surface per hour. That the temperature rise is from 55 to 100° F.

Building "A"

Cubic contents of building = 74,582 cu. ft.

$$\frac{35 \times 74,582 \times 2}{35} = 98,368 \text{ BTU}$$

Steam.

BTU supplied per hour (143,450 + 98,368) = 241,818
Available heat per pound steam at 212° = 970 BTU
241,818 ÷ 970 = 248.27 lbs. steam in one hour, or 175.8 in one day.
weather.

Building "B"

Cubic contents of building = 137,804 cu. ft.

$$\frac{35 \times 137,804 \times 2}{35} = 175,125 \text{ BTU}$$

Steam.

BTU supplied per hour (2,000,000 + 175,125) = 2,175,125
Available heat per pound steam at 212° = 970 BTU
2,175,125 ÷ 970 = 2,242.5 lbs. steam in one hour, or 1,714 in one day.
weather.

Building "C"

Cubic contents of building = 45,400 cu. ft.

$$\frac{35 \times 45,400 \times 2}{35} = 45,400 \text{ BTU}$$

Steam.

BTU supplied per hour (3,000,000 + 45,400) = 3,045,400
Available heat per pound steam at 212° = 970 BTU
3,045,400 ÷ 970 = 3,139.6 lbs. steam in one hour, or 2,512 in one day.
weather.

Steam Consumed in Early Morning Heating

Winter Season

In the present day office building the steam is generally in the heating system until nine o'clock in the evening. At this time the building is closed and as the doors and windows are all shut, the temperature of the building will fall quite slowly, and except in extreme cold weather will not be below 50° F. by six o'clock in the morning, at which time live steam is turned into the heating system. Assuming this to be the case it is then necessary to heat a volume of air equal to the cubic contents of the buildings from 50° F. to 70° F. This heating is to be done from six to eight o'clock in the morning with live steam, and will be assumed to be 5° in each half hour; or the rate per hour at which the steam must be supplied will be as follows:

The total cubic contents = 6355694 cu. ft.

Allow one air change per hour

Allow that one B.T.U. will raise the temperature 55 cu. ft. one degree.

Steam required to raise this volume from 50° to 70° is:

$$\frac{2 \times 6355694}{55} \times \frac{20}{970} = 4766\#$$

To raise this volume from 55° to 70° requires:

$$\frac{2 \times 6355694}{55} \times \frac{15}{970} = 3574\#$$

To raise this volume from 60° to 70° requires:

$$\frac{2 \times 6355694}{55} \times \frac{10}{970} = 2383\#$$

To raise the volume from 65° to 70° requires:

$$\frac{2 \times 6355694}{55} \times \frac{5}{970} = 1192\#$$

In the present day office building the steam is generally in the heating system until nine o'clock in the evening. At this time the building is closed and as the doors and windows are all shut, the temperature of the building will fall quite slowly, and except in extreme cold weather will not be below 50° F. by six o'clock in the morning, at which time live steam is turned into the heating system. Assuming this to be the case it is then necessary to heat a volume of air equal to the cubic contents of the building from 50° F. to 70° F. This heating is to be done from six to eight o'clock in the morning with live steam, and will be assumed to be 5° in each half hour; on the last half hour at which the steam must be supplied will be as follows:

The total cubic contents = 47000 cu. ft.
 Allow one air change per hour
 Allow that one B.T.U. will raise the temperature 55 cu. ft. one degree.

Steam required to raise this volume from 50° to 70° is:

$$\frac{2 \times 47000 \times 20}{55} = 47000 \#$$

To raise this volume from 55° to 70° requires:

$$\frac{2 \times 47000 \times 15}{55} = 3274 \#$$

To raise this volume from 60° to 70° requires:

$$\frac{2 \times 47000 \times 10}{55} = 2367 \#$$

To raise the volume from 65° to 70° requires:

$$\frac{2 \times 47000 \times 5}{55} = 1184 \#$$

HOURLY STEAM CONSUMPTION FROM DAILY LOAD CURVES.
Summer Season.

Time	Unit	H.P.	% Full Load	Steam per H.P. Hour	Steam per Hour
5-7 AM	1	75	60	30.8	2310
8	3	225	53	17.2	3880
9	3	225	93	15.5	3490
10	3	225	106	15.8	3560
11	3	225	106	15.8	3560
12	3	225	106	15.8	3560
1 Noon	3	225	100	15.7	3530
2 PM	3	225	100	15.7	3530
3	3	225	100	15.7	3530
4	3	225	100	15.7	3530
5	3	225	106	15.8	3560
6	3	225	127	16.8	3780
6:30	2	150	130	16.5	2480
7	2	150	100	16	2400
8	2	150	80	15.9	2380
9	2	150	80	15.9	2380
10	1	75	120	29.8	2240
11	1	75	70	30.1	2260
12 MN	1	75	40	32.8	2460
1-5 AM	1	75	30	34.8	2610

HOTEL STAM CONSTRUCTION FROM 1911 TO 1914 (Continued)

Time	Unit	L.P.	% Full Load	Steam per Hour	Cost per Unit
9-11 AM	1	75	60	20.8	10.10
8	3	255	85	17.3	10.10
9	3	255	85	17.3	10.10
10	3	255	100	17.3	10.10
11	3	255	100	17.3	10.10
12	3	255	100	17.3	10.10
1 Noon	3	255	100	17.3	10.10
2 PM	3	255	100	17.3	10.10
3	3	255	100	17.3	10.10
4	3	255	100	17.3	10.10
5	3	255	100	17.3	10.10
6	3	255	100	17.3	10.10
6:30	2	150	100	17.3	10.10
7	2	150	100	17.3	10.10
8	2	150	100	17.3	10.10
9	2	150	100	17.3	10.10
10	1	75	100	17.3	10.10
11	1	75	100	17.3	10.10
12 PM	1	75	100	17.3	10.10
1-2 AM	1	75	100	17.3	10.10

HOURLY STEAM CONSUMPTION FROM DAILY LOAD CURVES.
Winter Season

21

Time	Unit	H.P.	% Full Load	Steam per H.P.Hour	Steam per Hour
5-7 AM	1	75	60	30.8	2310
8	3	225	73.5	16.0	3540
9	(3	225	100	15.7	3530)
	(2	150	100	16.0	2400)
10	(3	225	120	16.5	3720)
	(2	150	120	16.3	2440)
11	(3	225	127	16.8	3780)
	(2	150	127	16.4	2460)
12 Noon	(3	225	116	16.2	3640)
	(2	150	116	16.2	2430)
1 PM	(3	225	96	15.6	3510)
	(2	150	96	16.0	2400)
2	(3	225	92	15.4	3460)
	(2	150	92	15.9	2380)
3	(3	225	98	15.6	3510)
	(2	150	98	16.0	2400)
4	(3	225	110	16.0	3600)
	(2	150	110	16.1	2420)
5	(3	225	127	16.8	3780)
	(2	150	127	16.4	2460)
5:30	(3	225	136	17.0	3830)
	(2	150	136	16.6	2490)
6	(3	225	88	15.5	3490)
	(2	150	88	15.9	2390)
6:30	2	150	130	16.5	2480

6:30 PM to 5:00 AM - - Conditions as for Summer load.

6:30 PM to 6:00 AM - Conditions as per Weather Report.

Time	Unit	H.P.	Full Load	Steam per H.P.	Water per Hour
6:30	2	150	130	16.3	2480
6	(2)	120	88	15.9	2200
	()				2480
5:30	(2)	150	136	15.6	2480
	()				2480
5:00	(2)	150	136	15.0	2480
	()				2480
4	(2)	150	110	16.1	2480
	()				2480
3	(2)	150	127	15.8	2480
	()				2480
2	(2)	150	127	15.4	2480
	()				2480
1 PM	(2)	150	98	15.0	2480
	()				2480
12 Noon	(2)	150	116	15.8	2480
	()				2480
11	(2)	150	127	16.4	2480
	()				2480
10	(2)	150	127	16.8	2480
	()				2480
9	(2)	150	100	16.0	2480
	()				2480
8	(2)	150	100	15.7	2480
	()				2480

Winter Season

HONOLULU STEAM CO. LTD. DAILY LOAD SUMMARY.

Hourly Steam Consumption of Engines.

'A' Winter Months.

'B' Summer Months.

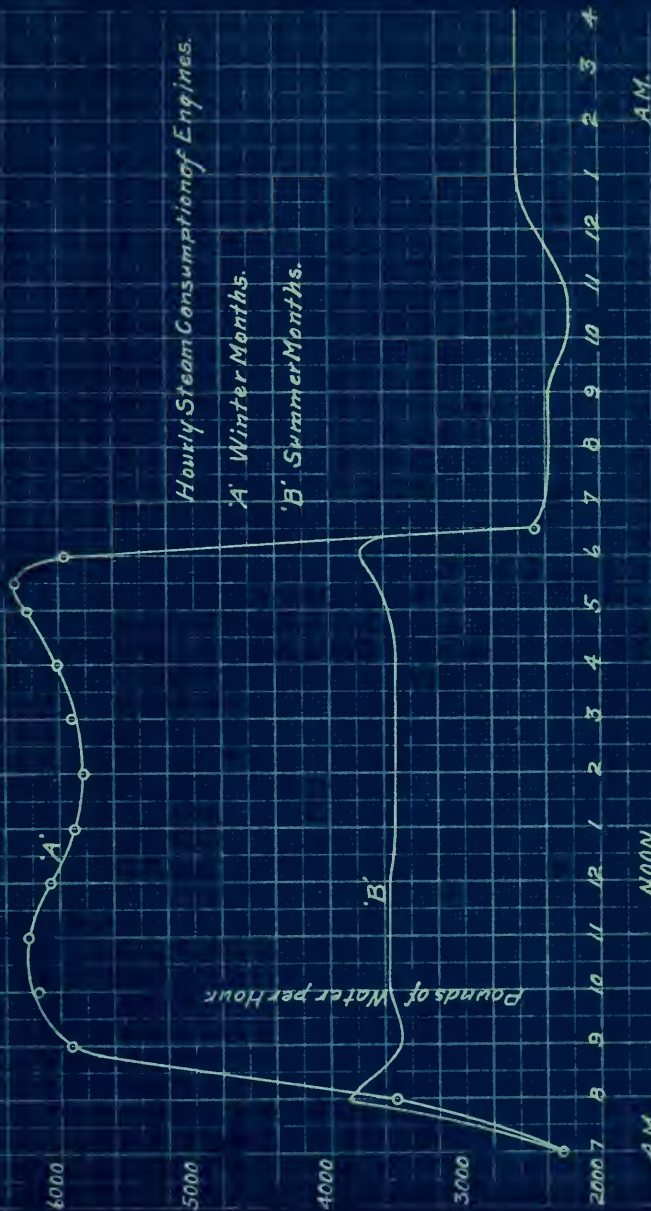


Figure 7.

Size of Pipe to Carry Steam to Buildings "A" and "B".

From Kent we have the following formula:

$$Q = 60 \times .7854 \times 50 D^2 \left\{ \frac{144 (p_1 - p_2) D}{WL} \right\}^{1/2}$$

Where: p_1 = initial pressure of steam
 p_2 = final " of steam
 W = weight per cu. ft. of steam at p_2
 D = diameter of pipe in feet
 L = length of pipe in feet
 Q = quantity of steam flowing per minute in cu. ft.

Weight of steam necessary 6326# per hour = 2775 cu. ft. per minute.

$$2775 = 2356 D^{5/2} \left\{ \frac{144 (25 - 15)}{(.0614 \times 1162)} \right\}^{1/2}$$

$$D^{5/2} = \frac{2775}{10555} \text{ or } D^5 = \frac{2}{.2629}$$

$$D = .5860 \text{ ft.} = 7"$$

Computation based on needs of the most severe weather.

Size of pipe to carry steam to engine "2" and "3".

From Kent we have the following formula:

$$Q = 60 \times 1.785 \times 10^{-5} \left\{ \frac{144 (P_1 - P_2)}{L} \right\} \sqrt{S}$$

Where: P_1 = initial pressure of steam
 P_2 = final " "
 W = weight per cu. ft. of steam at P_2
 D = diameter of pipe in feet
 L = length of pipe in feet
 Q = quantity of steam flowing per minute in cu. ft.

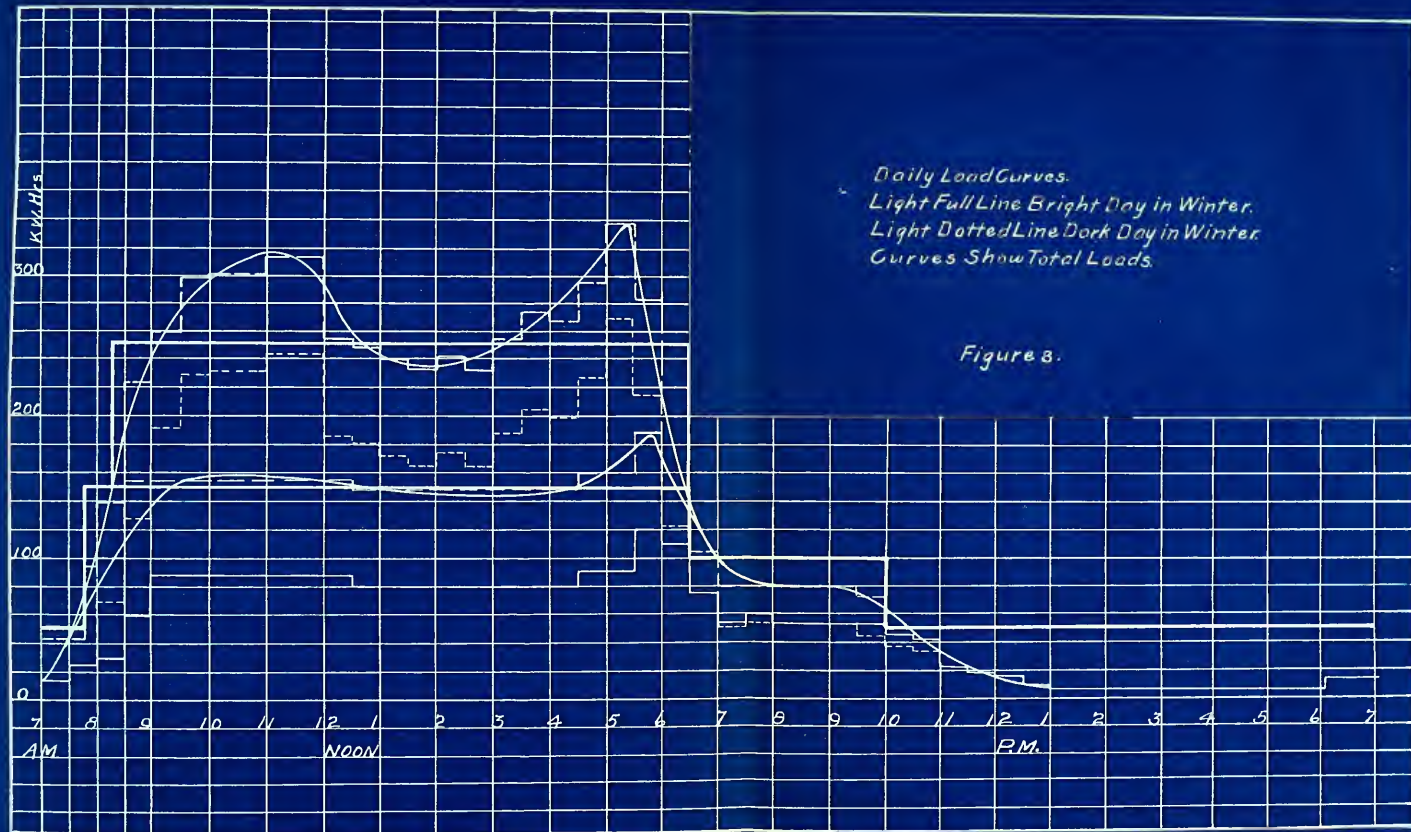
Weight of steam necessary 3300 per hour = 5500 cu. ft. per minute.

$$5500 = 60 \times 1.785 \times 10^{-5} \left\{ \frac{144 (150 - 100)}{L} \right\} \sqrt{S}$$

$$D^2 \sqrt{S} = \frac{5500}{1.785} \text{ or } D = \frac{3098}{\sqrt{S}}$$

$$D = 1.680 \text{ ft.} = 20"$$

Computation based on needs of the most severe condition.



Size Of Electrical Units.

In this determination two load curves, one for a bright day and one for a dark, foggy day, both in winter time, were obtained from an office building where conditions were similar to these to be considered. The ordinates of these curves were effected by the ratio of the rentable floor area of the building to which the curves applied, to the rentable floor area of the building under consideration. This gives two loads; they are for the lighting only, and to each was added the power necessary to operate the elevators. The two curves thus constructed are assumed to be maximum daily conditions for summer and winter months.

From these curves of maximum conditions the electrical units were determined and arranged to carry the load the most economically.

Unit #1	-	-	-	-	-	50	K W
" #2	-	-	-	-	-	100	K W
" #3	-	-	-	-	-	150	K W
" #4	-	-	-	-	-	150	K W

Size of Steam Units.

Allow an efficiency of 95% in the electrical units and an efficiency of 90% for the steam units.

$$\begin{aligned} 1 \text{ K W} &= 1000 \text{ Watts} \\ 1 \text{ H P} &= 746 \text{ "} \end{aligned}$$

$$\text{Therefore } \frac{1000}{746} = 1.34 \text{ Electrical horsepower}$$

$$1.34 + 5\% = 1.407 \text{ Brake horsepower}$$

$$1.407 + 10\% = 1.55 \text{ Indicated horsepower}$$

Or roughly add 50% to the rated capacity of the electric unit expressed in kilowatts for the indicated horsepower of the steam unit.

212 07-19-1947

In this determination two long curves, one for a dark day and one for a light day, both in winter time, were obtained from an office building where conditions were similar to those to be considered. The ordinates of these curves were selected by the ratio of the rentable floor area of a building to which the curves applied, to the rentable floor area of the building under consideration. This gives two local feet, one for the lighting coils, and to each was added the power necessary to operate the elevators. The two curves thus constructed are assumed to be suitable design conditions for summer and winter months.

are determined and measured in terms of the cost economically from these curves of marginal conditions the ecological units.

1944	08	-	-	-	-	10	1000
1945	08	-	-	-	-	10	1000
1946	08	-	-	-	-	10	1000
1947	08	-	-	-	-	10	1000

1100 1150 1200 1250 1300 1350 1400 1450 1500 1550 1600 1650 1700 1750 1800 1850 1900 1950 2000 2050 2100 2150 2200 2250 2300 2350 2400 2450 2500 2550 2600 2650 2700 2750 2800 2850 2900 2950 3000 3050 3100 3150 3200 3250 3300 3350 3400 3450 3500 3550 3600 3650 3700 3750 3800 3850 3900 3950 4000 4050 4100 4150 4200 4250 4300 4350 4400 4450 4500 4550 4600 4650 4700 4750 4800 4850 4900 4950 5000 5050 5100 5150 5200 5250 5300 5350 5400 5450 5500 5550 5600 5650 5700 5750 5800 5850 5900 5950 6000 6050 6100 6150 6200 6250 6300 6350 6400 6450 6500 6550 6600 6650 6700 6750 6800 6850 6900 6950 7000 7050 7100 7150 7200 7250 7300 7350 7400 7450 7500 7550 7600 7650 7700 7750 7800 7850 7900 7950 8000 8050 8100 8150 8200 8250 8300 8350 8400 8450 8500 8550 8600 8650 8700 8750 8800 8850 8900 8950 9000 9050 9100 9150 9200 9250 9300 9350 9400 9450 9500 9550 9600 9650 9700 9750 9800 9850 9900 9950 10000

no bad action is to be taken and it is to be maintained as a whole
the same as it is now and it is to be maintained as a whole

$$\frac{d^4}{dt^4} \left(\frac{1}{t} \right) = \frac{24}{t^5} = \frac{24}{t^5} \cdot \frac{1}{t^5} = \frac{24}{t^{10}}$$

Therese's 1000 - 1.34 Electric car

$$\begin{aligned} \text{Total cost of } T_{0A.I} &= 75 + 18.1 \\ \text{Total cost of } T_{0B.I} &= 90 + 104.1 \end{aligned}$$

10. The electric cable of the electric unit is connected to the electric unit.

Economy of The Steam Units.

These curves of engine economy are deductions from similar curves taken from "The Economy Factors in Steam Power Plants" by Geo. W. Hawkins.

Hourly Steam Consumption.

The curves of hourly steam consumption were plotted from the load curves and engine economy curves, i.e., for each hour of day from the load curve was taken the per cent. of full load at which the units were operating. With this percentage from the economy curve is found the water rate of the particular steam unit. These values multiplied by the horsepower of the unit gives the steam consumption per hour.

Economy of the Steam Unit.

These curves of engine economy are deduced from similar curves taken from "The Economy Factors in Steam Power Plants" by Geo. W. Hawkins.

Hourly Steam Consumption.

The curves of hourly steam consumption were plotted from the load curves and engine economy curves, 1.6, for each hour of day from the load curve was taken the per cent. of full load at which the units were operating. This full percentage from the economy curve is found the water rate of the particular steam unit. These values multiplied by the horsepower of the unit gives the steam consumption per hour.

Estimate of the Electrical Current Consumed
In Buildings "A", "B" & "C".

Lighting for Tenants -

This estimate is computed on the basis of the rented floor area. The data was obtained on a typical office building; one which furnished its tenants with electrical current for lighting.

The actual current consumed by the tenants divided by the total area of rentable floor space gives the current necessary for lighting per sq. foot.

Lighting for Halls -

The total area of floor space less the rented area is considered as halls; and as above the current used for lighting this area divided by the area gives the current necessary for lighting per sq. foot of halls.

Current for Elevators -

The current consumed in Buildings "A" and "B" is known, the meter readings having been obtained from the engineer in charge. The current for Building "C" was estimated from that consumed in Building "A", the method used being that for estimating the lighting.

Estimate Of Electric Current Consumed Per Year.

Building	For Tenants Light & Power	House
"A"		
47275 sq.ft. @ 733 Watts sq.ft.	34653 KW Hrs.	
15764 " " "1520 " " "		23961 KW Hrs.
"B"		
88926 sq.ft.@ 733 Watts sq.ft.	65183 KW Hrs.	
12126 " " " 1520 " " "		18432 KW Hrs.
"C"		
259056 sq.ft.@ 733 Watts sq.ft.	189888 KW Hrs	
86352 " " " 1520 " " "		131255 KW Hrs.
For Motor load:		
259056 sq. ft.@ 500 Watts " "	129525	
"A"		
Current to Elevators actual		58032
House and Bilge pumps "		3849
"B"		
Current to Elevators actual		35287
House and Bilge pumps "		1727
"C"		
Current to Elevators Estimate		
259056 sq. ft. @ 396 Watts per sq. ft.		102586
House and Bilge pumps		
259056 sq. ft. @ 19.4 Watts per sq. ft.		<u>50257</u>
	419249	425386
Total to be generated		844635 KW Hrs.

Estimate Of Electric Current Consumed Per Year.

Building	For Tenants Light & Power	House
"A"		
15784 " " "1250 "	47275 ad.ft. @ 733 Watts ad.ft.	34653 KW Hrs.
		23961 KW Hrs.
"B"		
15132 " " "1250 "	88926 ad.ft. @ 733 Watts ad.ft.	65153 KW Hrs.
		16432 KW Hrs.
"C"		
86322 " " "1250 "	259056 ad.ft. @ 733 Watts ad.ft.	193253 KW Hrs.
	For Motor Load:	
259056 ad.ft. @ 500 Watts " "		
"A"		
Current to Elevators actual		57032
House and Bldg pump		3949
"B"		
Current to Elevators actual		35257
House and Bldg pumps		1727
"C"		
Current to Elevators Estimate		102586
259056 ad.ft. @ 396 Watts per ad.ft.		
House and Bldg pumps		
259056 ad.ft. @ 114 Watts per ad.ft.		30527
		450348
	412243	
Total to be generated		844520 KW Hrs.

Bldg.	No. in Operation	Start- ing Time	Stop- ping Time	Hours per Day	Time for Single Trip	Trips per Day	Single Trips per year	Current consump- tion per year	Current consump- tion per trip
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[illegible][illegible]

Det'd on 14-10-07.

[illegible]

Day	Time	Location	Remarks
Sunday	9:00AM	1 PM	4
	7:45AM	6 PM	20
	7:00AM	10PM	15
	10:00	40000	50
	1470	1470	50
	1870	1870	50

Time	Activity	Person	Remarks
7:00 AM	Arrival	John	1st
7:45 AM	Departure	John	1st
7:00 AM	Arrival	John	1st

Estimate of Cost of Power Plant Equipment.

4 - 250 H.P. water tube boilers, sectional header, in place	11000.00
4 - chain grate stokers each 7 ft. x 9 ft. = 63 sq. ft. with two engines, shafting, pulleys, etc., in place-	3780.00
Boiler foundations - - - - -	1000.00
Boiler settings - - - - -	3000.00
Coal and ash conveyer and bunkers in place - - - - -	
Conveyer 272 ft. @ \$20.00 - -	\$5440.00
Driver - - - - -	400.00
4 green coal pans and valves - -	176.00
4 coal bunkers - - - - -	2000.00
	7976.00
Chimney, steel lined 72" x 200 ft. - - - - -	4200.00
Breeching - - - - -	800.00
Heater - - - - -	600.00
2 feed pumps - ram pattern - - - - -	750.00

Engines and generators, horizontal high speed direct connected
to 220 volt d. c. Generators:

1 - 75 H.P. simple Engine - - -	1130.00
1 - 50 K W generator - - -	1000.00
1 - 150 H.P. compound engine - -	2100.00
1 - 100 K W generator - - -	1500.00
2 - 225 H.P. Compound engines - -	5500.00
2 - 150 K W generator - - -	5000.00
	16230.00

1 surface condenser with vacuum pump and circulating pump	1200.00
Piping, steam, exhaust and water, in place - - - - -	4000.00
Miscellaneous and engineering 10% - - - - -	5454.00

Cost per K W \$ 133.00
Cost per boiler H.P. 60.00

Or say \$ 59990.00
60000.00

Note: The above estimated cost p. KW. is not unreasonable as about one-half of the boiler plant investment (or about \$14,000.) is required for heating, making the cost of the electric plant \$46,000. or \$102.00 per KW.

Estimate of Cost of Power Plant Development.

4 - 250 H.P. water turbine boliers, additional boiler, in place	1100.00
4 - chain drive sprockets each 7 ft. x 3 ft. = 28 ft.	
With two engines, shafting, pulleys, etc., in place	2750.00
Boiler foundations	1000.00
Boiler settings	3000.00
Coal and ash conveyor and bunkers in place	
Conveyer 275 ft. @ \$20.00	\$5400.00
Driver	400.00
4 green coal pans and valves	150.00
4 coal bunkers	2000.00
Chimney, steel lined 75" x 100 ft.	
Breaching	
Heater	
Feed pumps - ran pattern	
	750.00
	500.00
	500.00
	4500.00
	7975.00

Enclines and generators, vertical, 1000 watt direct connected to 220 volt a.c. generators;

QTY	DESCRIPTION	UNIT PRICE	TOTAL
1	75 H.P. Simple Engine	1150.00	1150.00
1	50 K.W. Generator	1000.00	1000.00
1	150 H.P. compound engine	1500.00	1500.00
1	100 K.W. Generator	1500.00	1500.00
2	225 H.P. compound engines	2500.00	5000.00
2	100 K.W. Generator	2000.00	4000.00
1	surface condenser with water pump and circulating pump	1000.00	1000.00
1	Piping, steam, exhaust and water, in place	4000.00	4000.00
1	Miscellaneous and engineering 10%	444.00	444.00
1	Subtotal	20190.00	20190.00
1	Grand Total	20000.00	20000.00

Cost per roller 1.90
Cost per KW 4.15/00

Note: The above estimated cost of 1 KW. is not comparable to a conventional boiler plant investment (or about \$14,000.) is required for heating, making the cost of the electric plant \$40,000. or \$102.00 per KW.

50000 KWH Hours

Current Consumed per Month by Tenants
For Lighting

Months

Figure 9.

12

11

10

9

8

7

6

5

4

3

2

1

40

30

20

15

10

5000

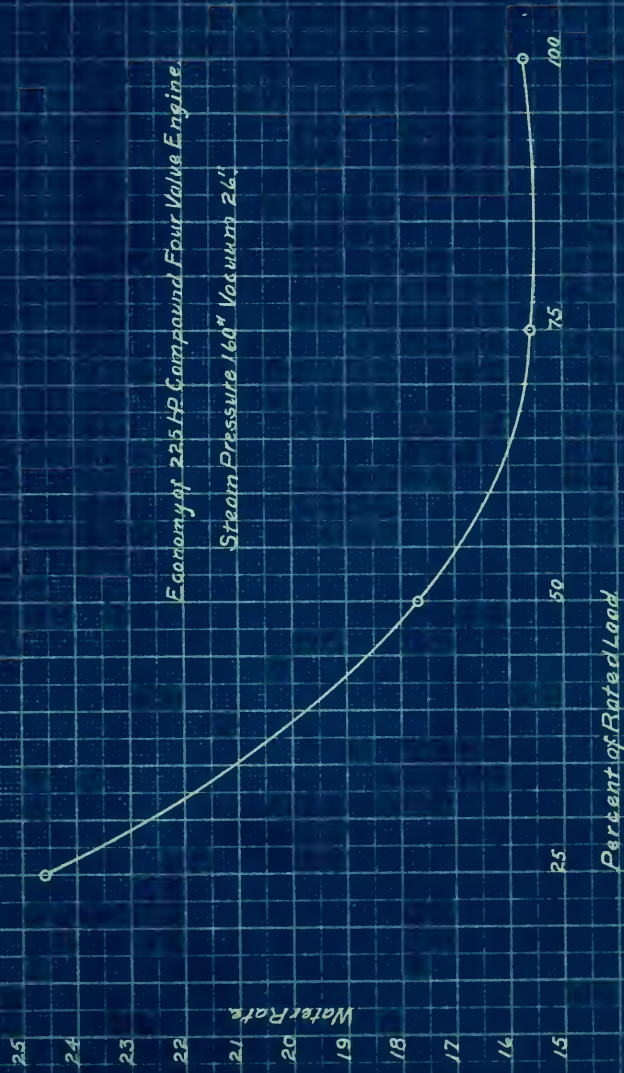


Figure 10.

26
25
24
23
22
21
20
19
18
17
16
15

Water Rate

25

50

75

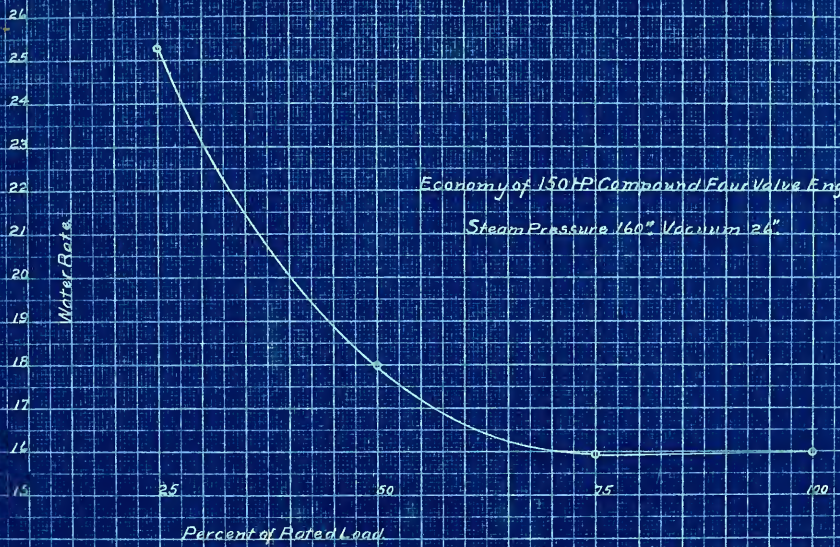
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Percent of Rated Load

Economy of 150HP Compound Four Valve Engine

Steam Pressure 160" Vacuum 26"

Figure 11.



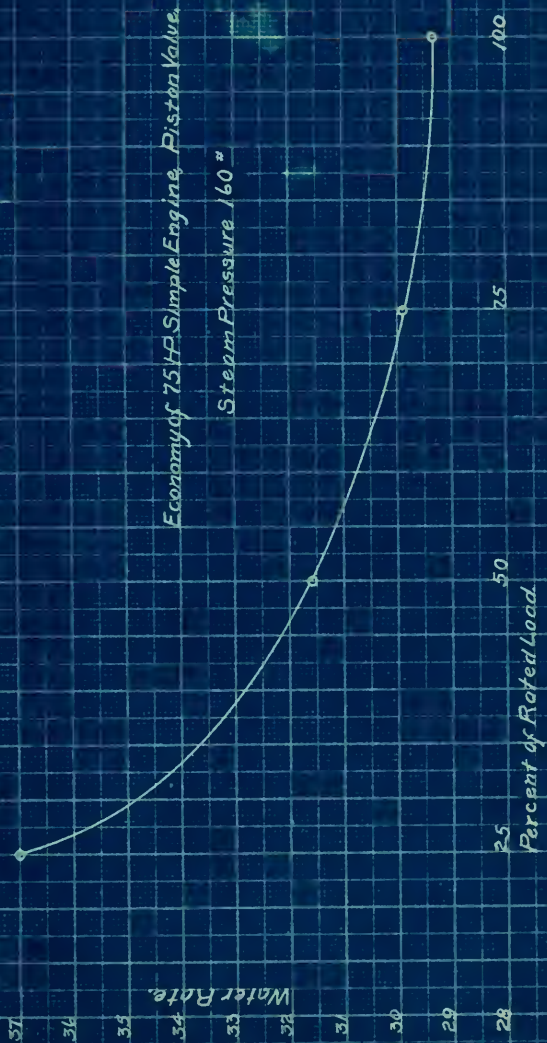
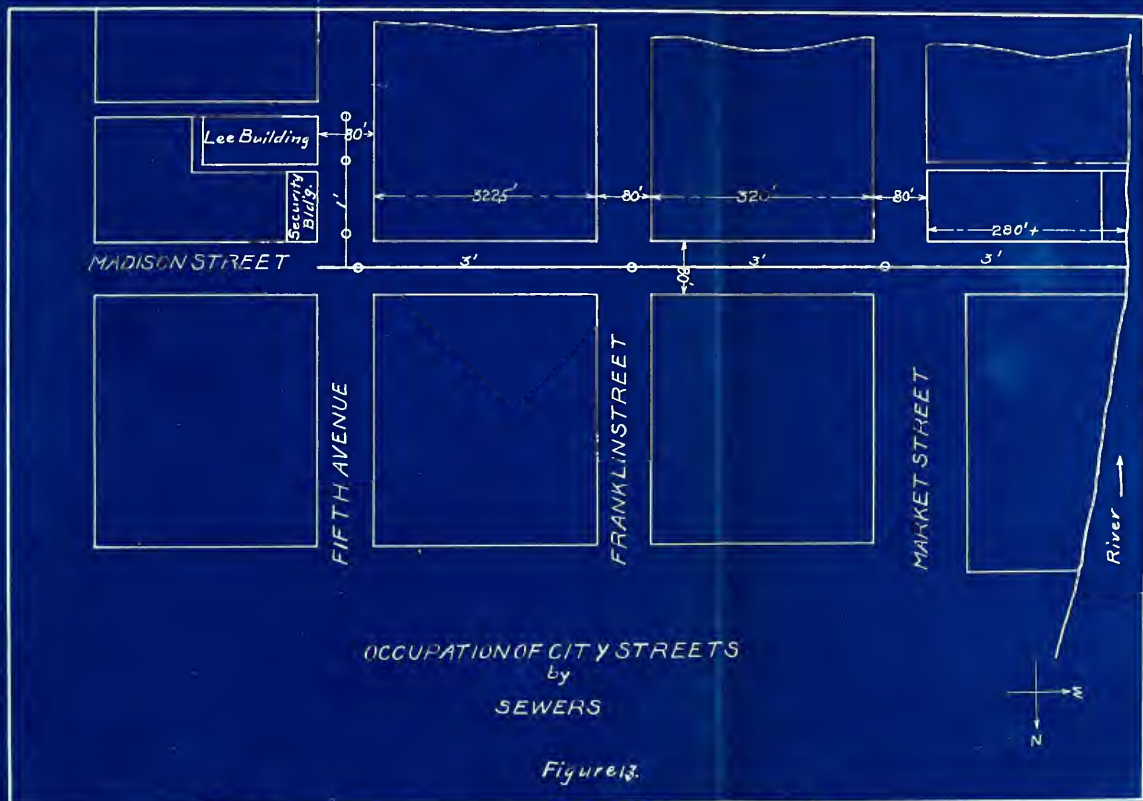
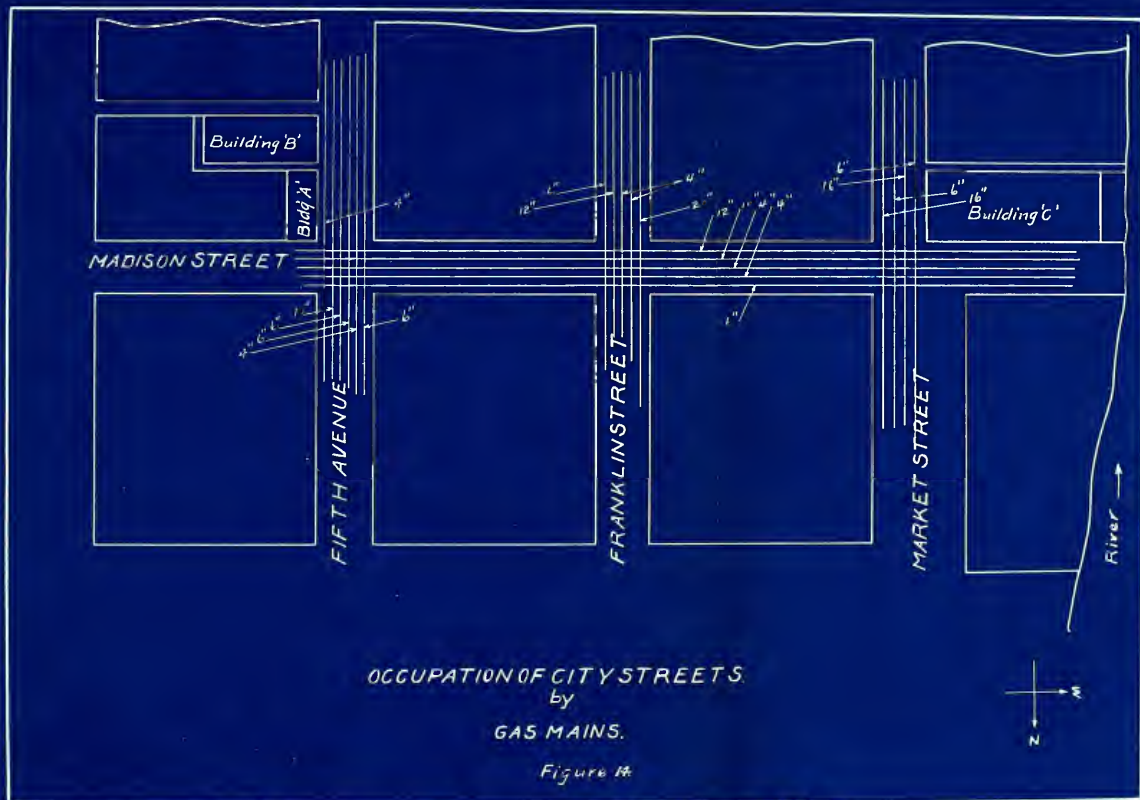


Figure 12.











OCCUPATION OF CITY STREETS
by
TUNNEL SYSTEM

Figure 15.









